FOXSI to observe X-rays from Sun

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Installing state-of-the-art optics onto the Focusing Optics X-ray Solar Imager, or FOXSI, mission, which will observe hard X-rays from the sun. Credit: NASA/FOXSI

An enormous spectrum of light streams from the sun. We're most familiar with the conventional visible white light we see with our eyes from Earth, but that's just a fraction of what our closest star emits. NASA regularly watches the sun in numerous wavelengths because different wavelengths provide information about different temperatures and processes in space. Looking at all the wavelengths together helps to provide a complete picture of what's occurring on the sun over 92 million miles away - but no one has been able to focus on high energy X-rays from the sun until recently.

In early December 2014, the Focusing Optics X-ray Solar Imager, or FOXSI, mission will launch aboard a sounding rocket for a 15-minute flight with very sensitive hard X-ray optics to observe the sun. This is FOXSI's second flight - now with new and improved optics and detectors. FOXSI launched previously in November 2012. The mission is led by Säm Krucker of the University of California in Berkeley.

Due to launch from White Sands Missile Range in New Mexico, on Dec. 9, 2014, FOXSI will be able to collect six minutes worth of data during the 15-minute flight. Sounding rockets provide a short trip for a relatively low price - yet allow scientists to gather robust data on various things, such as X-ray emission, which cannot be seen from the ground as they are blocked by Earth's atmosphere.

"Hard X-rays are a signature of particles accelerating on the sun," said Steven Christe, the project scientist for FOXSI at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "The sun accelerates particles when it releases magnetic energy. The biggest events like solar flares release giant bursts of energy and send particles flying, sometimes directed towards the Earth. But the sun is actually releasing energy all the time and that process is not well-understood."

Scientists want to understand these energy releases both because they contribute to immense explosions on the sun that can send particles and energy toward Earth, but also because that energy helps heat up the sun's atmosphere to temperatures of millions of degrees—1,000 times hotter than the surface of the sun itself. Observing many wavelengths of light allows us to probe different temperatures within the sun's atmosphere. Looking for hard X-rays, is not only one of the best ways to measure the highest temperatures, up to tens of millions of degrees, but it also helps track accelerated particles.

The FOXSI team poses with the rocket, which is scheduled to launch in early December 2014. FOXSI will look for signatures of small solar flares, called nanoflares, on the sun during its 15-minute flight. Credit: NASA/FOXSI

The sensitivity of the FOXSI instrument means the team can investigate very faint events on the sun, including tiny energy releases commonly known as nanoflares. Nanoflares are thought to occur constantly, but are so small that we can't see them with current telescopes. Spotting hard X-rays with FOXSI would be a confirmation that these small flares do exist. Moreover, it would suggest that nanoflares behave in a similar fashion as larger flares, accelerating particles in much the same way that big flares do.

"It's not necessarily true that these small flares accelerate particles. Perhaps they are just small heating events and the physics is different," said Christe. "That's one of the things we're trying to figure out."

Viewing such faint events requires extra sensitive optics. FOXSI carries something called grazing-incidence optics—built by NASA's Marshall Space Flight Center in Huntsville, Alabama—that are unlike any previous ones launched into space for solar observations. Techniques to collect and observe high energy X-rays streaming from the sun have been hampered by the fact that these wavelengths cannot be focused with conventional lenses the way visible light can be. When X-rays encounter most materials, including a standard glass lens, they usually pass right through or are absorbed. Such lenses can't, therefore, be used to adjust the X-ray's path and focus the incoming beams. So X-ray telescopes have previously relied on imaging techniques that don't use focusing. This is effective when looking at a single bright event on the sun, such as the large burst of X-rays from a solar flare, but it doesn't work as well when searching for many faint events simultaneously.

The FOXSI instrument makes use of mirrors that can successfully cause x-rays to reflect—as long as the x-ray mirrors are nearly parallel to the incoming X-rays. Several of these mirrors in combination help collect the X-ray light before funneling it to the detector. This focusing makes faint events appear brighter and crisper.

The FOXSI launch is scheduled for Dec. 9 between 2 and 3 pm EST. The shutter door on the optics system opens up after the payload reaches an altitude of 90 miles, one minute after launch. FOXSI then begins six minutes of observing the sun. After the observations, the door on the optics system closes. The rocket deploys a parachute and the instruments float down to the ground in the hopes of being used again.

The FOXSI mission made it through this process successfully once before, when it flew in 2012. On its first flight, the telescope successfully viewed a flare in progress. On this second flight, the team has updated some of the optics to be more sensitive and has removed insulation blankets that blocked some of the X-rays during the last flight. They also upgraded some of the detectors with new detectors built by the Japanese Aerospace Exploration Agency using a new detector material. Last time they used silicon and this time they are using cadmium telluride.

Such refurbishing illustrates a key value of sounding rockets: Making adjustments to the instruments on relatively low-cost flights has great benefit for future missions. By testing FOXSI on a sounding rocket, it can be perfected to use on a larger satellite with even larger, more sensitive optics.

In addition to developing technology, these low-cost missions help train students and young scientists.

"Sounding rockets are a great way for students to be heavily involved in every aspect of a space mission, from electronics testing to observational planning," said Lindsay Glesener, FOXSI's project manager at the University of California in Berkeley, who was also a graduate student during FOXSI's first flight. "Development on low-cost missions is the way that,scientists, engineers, and even the telescopes get prepared to work on an eventual satellite mission."

Provided by NASA's Goddard Space Flight Center